Topic 8: Body Systems – 8d. Respiratory/Circulatory Systems
8d1. VO_2 Max Lab

Resources: Miller, K., Levine, J. (2004). *Biology.* Boston, MA: Pearson Prentice Hall.

Macknight, J. VO_2 Max [Internet]. University of Virginia Health Systems. 16 Dec. 2008. Available from: http://www.healthsystem.virginia.edu/internet/nuclear-cardiology/vo2max.cfm

Building on: The circulatory and respiratory systems work together to deliver oxygen to the cells of your body so those cells can, under cellular respiration, produce the energy needed to do work. Work is influenced by the force applied over a distance. When you lift an object against the force of gravity, that is work. VO_2 max is a measure represents the efficiency of your skeletal muscles, circulatory and respiratory systems and their combined ability to do work. VO_2 max is influence by your mass, how high the step is that you will climb, how many steps you take, and how often your heart has to beat to allow you to do this. VO_2 max is also influenced by gender and age.

Links to Chemistry:
pH
Buffers
Lactic acid

Links to Physics:
Energy
Work
Force
Conservation of energy
Efficiency

Stories: VO_2 max is an indication of physical fitness. An improved VO_2 max is a reflection of good training and improved efficiency of the respiratory/cardio systems. The average couch potato will have a VO_2 max around 30-40 ml/kg/min; highly trained endurance athletes will be around 70-80 ml/kg/min. VO_2 max is greatly influenced by the blood output of the heart per minute. Aerobic cardio training can improve this. Lower body fat, even with no change in the total muscle mass will increase the VO_2 max. There are some limits that may be beyond a person's control. There is a genetic link that influences VO_2 max; there are genetic variations in the mitochondria that limit the efficiency of those organelles to convert energy into ATP. Women have a VO_2 max that is approximately 20% lower than men of the same weight and age. Age also plays a role. VO_2 max peaks around age 20 and then begins a decline. The degree of decline is dependent on the level of activity, gender and genetics of the individual.

Materials for the Lab:

- Meter stick
- Stop watch
- Steps (I use steps near my classroom that have a handrail.)
- Calculators

Instructions for the Teacher:

Warn the students the day before to wear comfortable shoes and comfortable clothes. Some will still show up in flip-flops, but you did warn them. I never force students to take the step test. If they choose not to participate they must use the data from someone else in the class. Rarely do I have a student opt. out.

I don't make students weigh themselves. I tell them to use what they think is their weight. When it is converted to kilograms, it becomes pretty meaningless to many of them.

Put the students in pairs so one steps while the other counts. I like using steps with a handrail because the students get uncoordinated as they tire and it helps to eliminate falls.
Remind them to take their pulse as soon as they finish. (That pulse should not be hard to find.)

I have found that it is easiest if I run the stopwatch, and I have about 12 students step at a time. I let them know when they have 2 minutes, 1 minute, and 30 seconds remaining.

Tell them that it is best to try to go at a steady pace for the three-minute test. They hardly ever listen—instead taking off like a horse out of the starting gate! Hence, the reason for question #4 in the lab.

Respiratory/Circulatory: VO_2 Max Lab

Introduction: The benefits of regular physical exercise are well known. Aerobic capacity can be measured in many different ways. In an exercise physiology laboratory, an individual's fitness can be measured directly by determining the maximum rate at which he/she can use oxygen. This rate is called VO_2 max and is measured in ml/kg/min. A VO_2 max value tells what volume of oxygen a person is using per minute. The higher the rate, the better shape the person is in. VO_2 max values are obtained by giving a person a maximum stress test. During this type of test, a person exercises until the point of exhaustion or until the test is stopped by the physiology. A VO_2 max can be estimated without use of highly specialized equipment. A number of tests have been developed or used with large numbers of people in a non-laboratory setting. One way to do this is by a timed run or using a step test.

Purpose: Write a purpose stating what you plan to do and what you're trying to determine.

Hypothesis: Guess what your actual VO_2 max will be, knowing that it will range somewhere between 0-100. Most very good athletes are around 85 ml/kg/min. Be sure to include a "because" in the sentence.

Procedure:

1. Determine your mass in kg (pounds/2.2 = kilograms) and record it on your Evidence Table.

2. Determine the height of the step being used and record it on the Evidence Table in meters.

3. The student will step for three minutes and his/her partner will count (up-up-down-down counts as one step) the total number of steps taken. Record this number in your Evidence Table.

4. Immediately after you finish stepping, you should take your pulse for 15 seconds. Record this information on your Evidence Table.

5. Calculate you VO_2 max using the equations below and recording your data on your Evidence Table.

Equations:

Pounds/2.2 = Kilograms

HR = 16.32 + (.93 X heart rate for 15 seconds)

P = Mass in kilograms X (# of steps/3) X height of step in meters X 1.35

VO_2 for Females = 6.85591 + (.00368 X P) – (.04338 X HR)

VO_2 for Males = 6.49104 + (.00368 X P) – (.04220 X HR)

VO_2 Max = VO_2 X 1000 / mass in kilograms

Evidence Table

Height of Step (meters)	
Total # of Steps Taken	
Pulse for 15 Seconds	
HR =	
P =	
VO_2 Female	
VO_2 Male	
VO_2 Max (ml/kg / min)	

Analysis Questions:

1. Tell how the sinoatrial (SA) node was vital to your ability to perform the step test.

2. What happened to the length of your cardiac cycle during the step test?

3. How did the valves in your heart help you perform the step test?

4. You may have started off very fast in the step test, this may have allowed you to take more steps, but it also raised your heart rate. Do you think your VO_2Max would be higher if you had completed the step test at a steady rate with few steps, but a lower heart rate? Explain your thinking.

5. What type of athlete do you think would have the highest VO_2 max, and why?

Conclusion:

NLQ: